FIG. 1

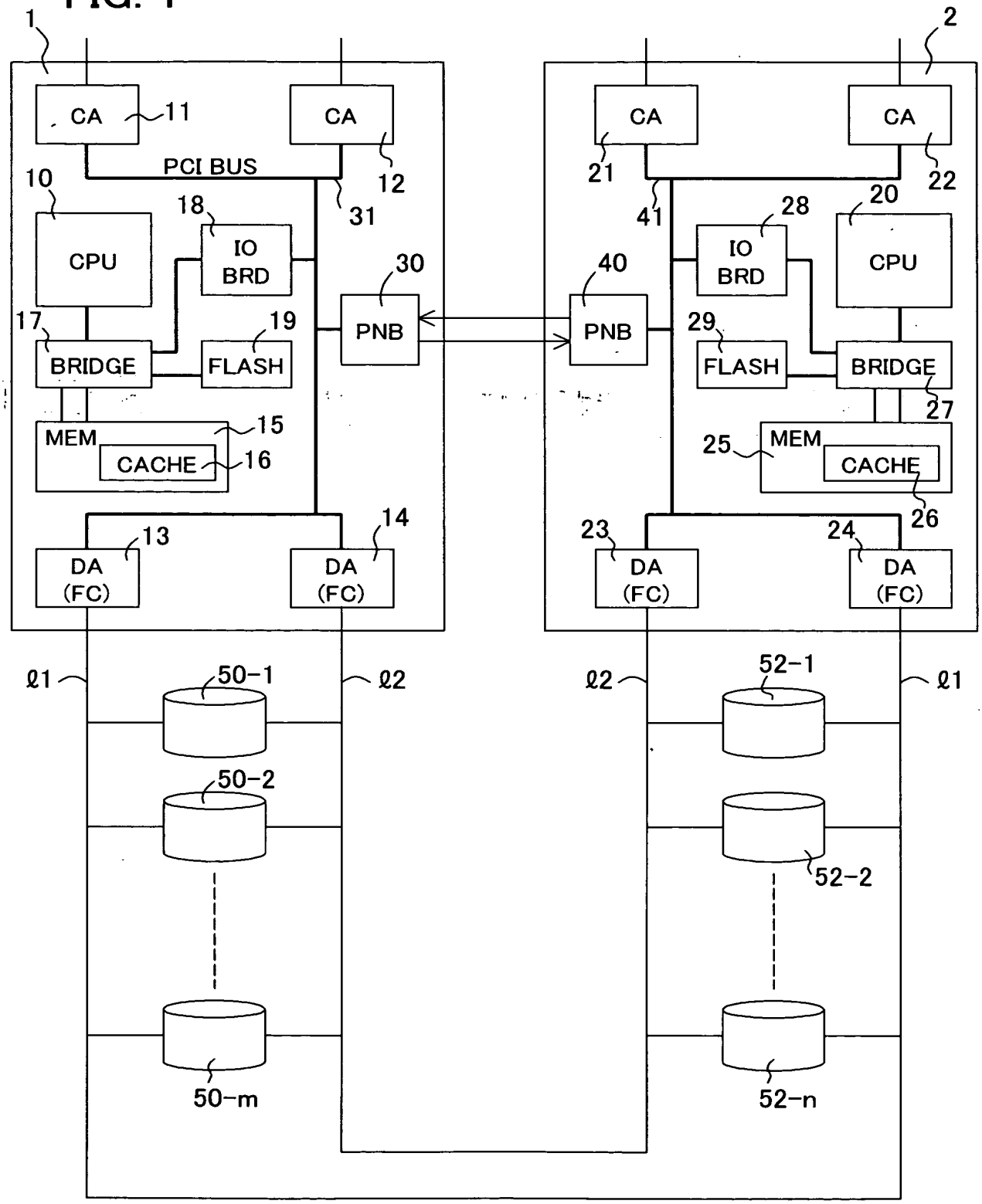

1
2
CA
11
CA
12
PCI BUS
31
10
CPU
18
IO BRD
30
PNB
17
BRIDGE
19
FLASH
MEM
15
CACHE
16
13
DA (FC)
14
DA (FC)
CA
21
CA
22
41
20
CPU
28
IO BRD
40
PNB
29
FLASH
BRIDGE
27
25
MEM
CACHE
26
23
DA (FC)
24
DA (FC)
ℓ1
50-1
ℓ2
50-2
50-m
ℓ2
52-1
ℓ1
52-2
52-n

FIG. 2

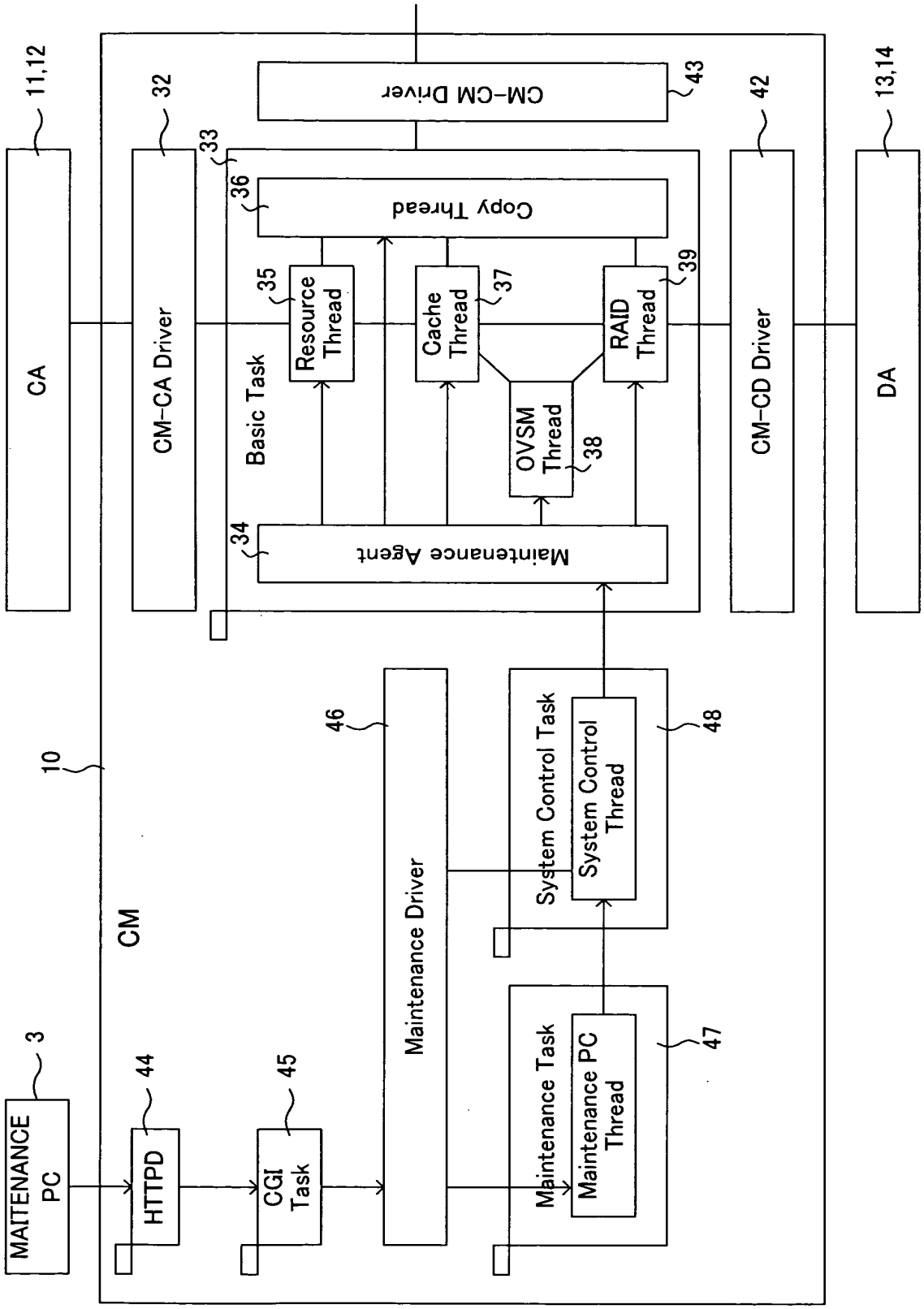

MAITENANCE PC
3
HTTPD
44
CGI Task
45
Maintenance Driver
46
Maintenance Task
Maintenance PC Thread
47
System Control Task
System Control Thread
48
CM
10
CA
11,12
CM-CA Driver
32
Basic Task
33
Resource Thread
35
Cache Thread
37
RAID Thread
39
OVSM Thread
38
Copy Thread
36
Maintenance Agent
34
CM-CM Driver
43
CM-CD Driver
42
DA
13,14

FIG. 3

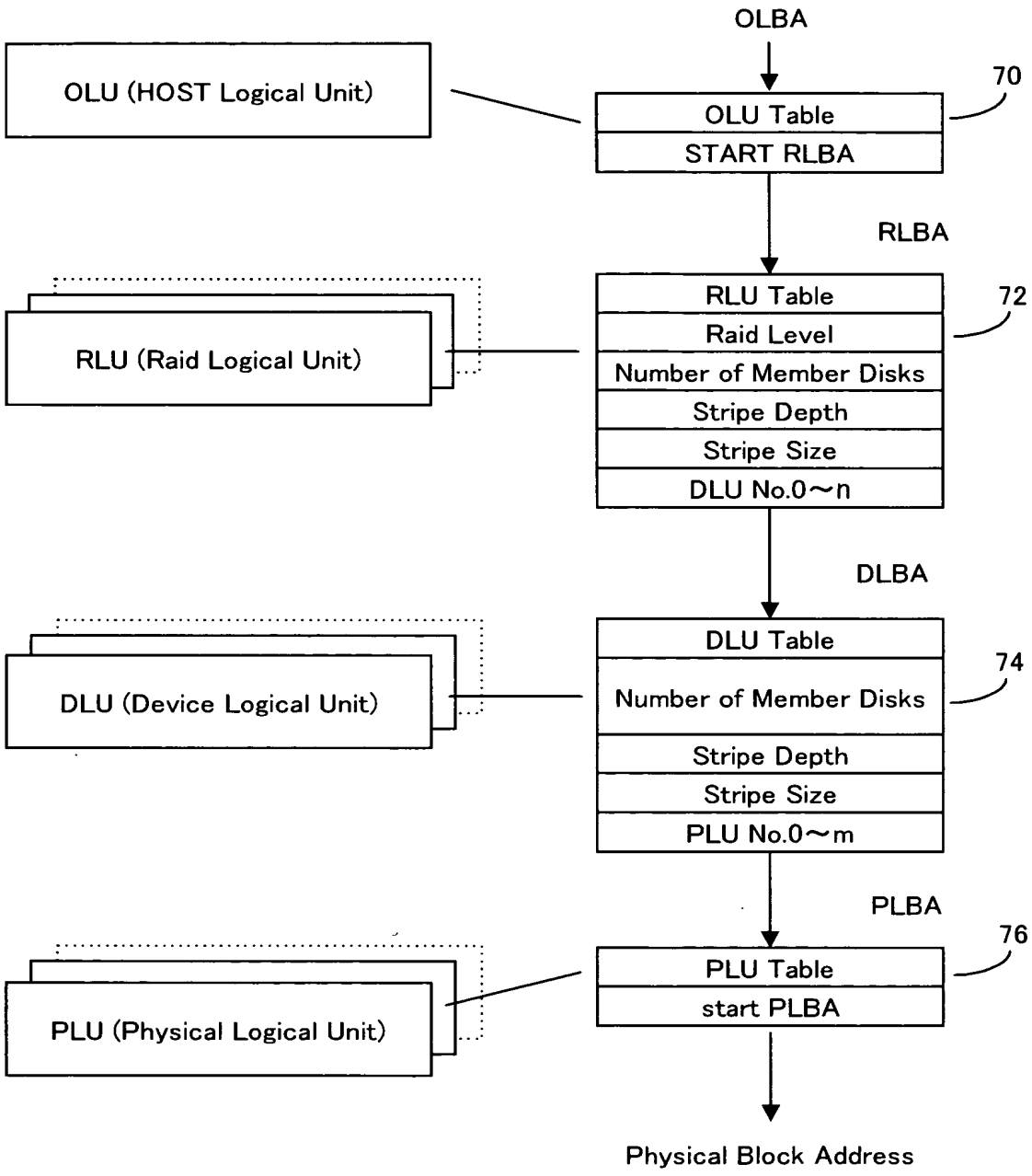
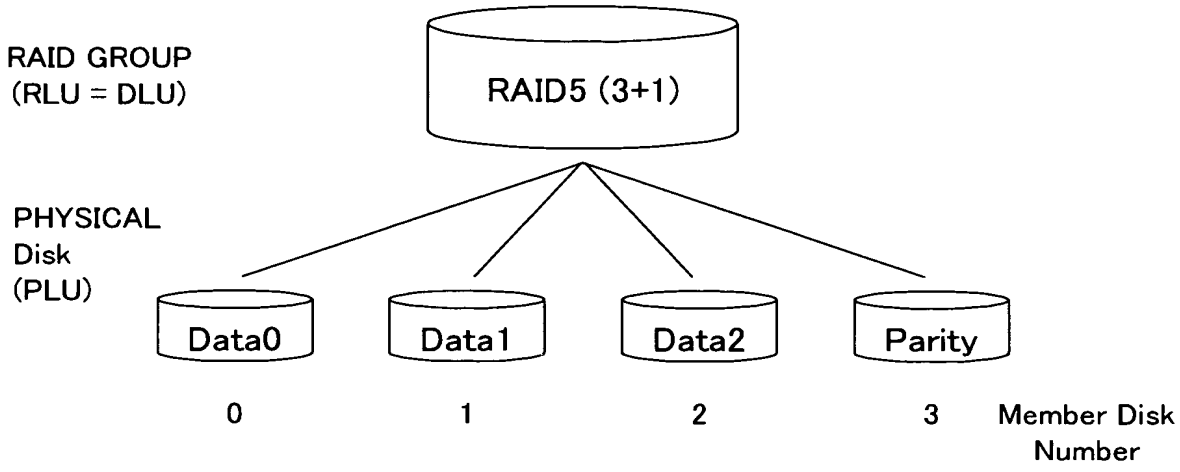

OLBA
OLU (HOST Logical Unit)
OLU Table
START RLBA
70
RLBA
RLU (Raid Logical Unit)
RLU Table
Raid Level
Number of Member Disks
Stripe Depth
Stripe Size
DLU No.0~n
72
DLBA
DLU (Device Logical Unit)
DLU Table
Number of Member Disks
Stripe Depth
Stripe Size
PLU No.0~m
74
PLBA
PLU (Physical Logical Unit)
PLU Table
start PLBA
76
Physical Block Address

FIG. 4


RAID GROUP
(RLU = DLU)
RAID5 (3+1)
PHYSICAL
Disk
(PLU)
Data0
Data1
Data2
Parity
0
1
2
3
Member Disk
Number

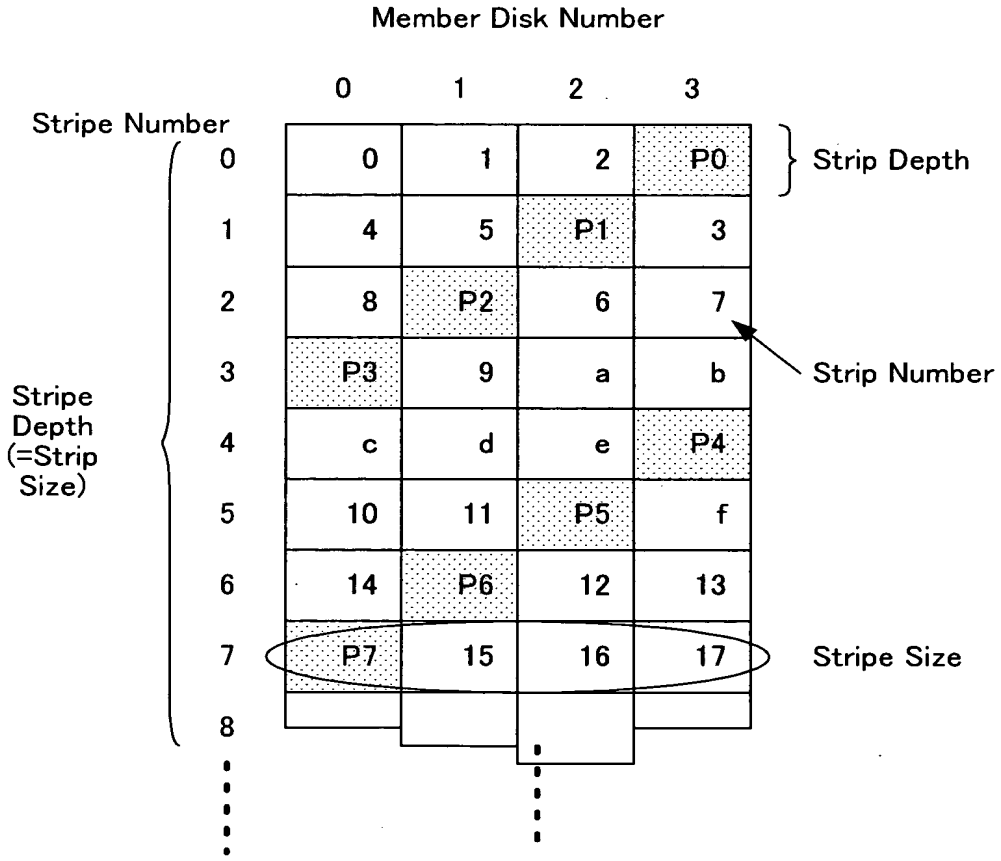

Member Disk Number
0
1
2
3
Stripe Number
0
1
2
3
4
5
6
7
8
0
1
2
P0
4
5
P1
3
8
P2
6
7
P3
9
a
b
c
d
e
P4
10
11
P5
f
14
P6
12
13
P7
15
16
17
Strip Depth
Strip Number
Stripe Size
Stripe
Depth
(=Strip
Size)

FIG. 5

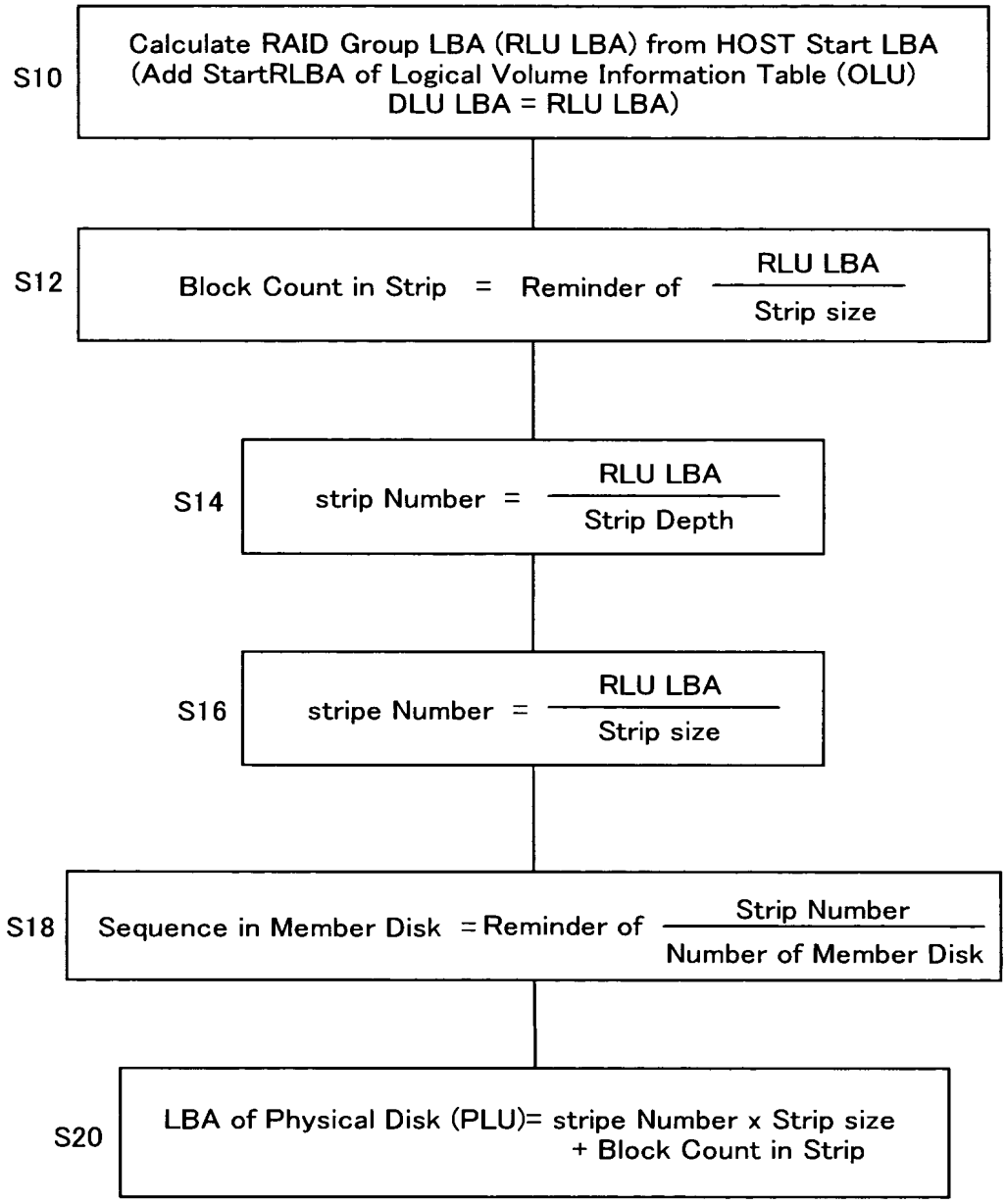
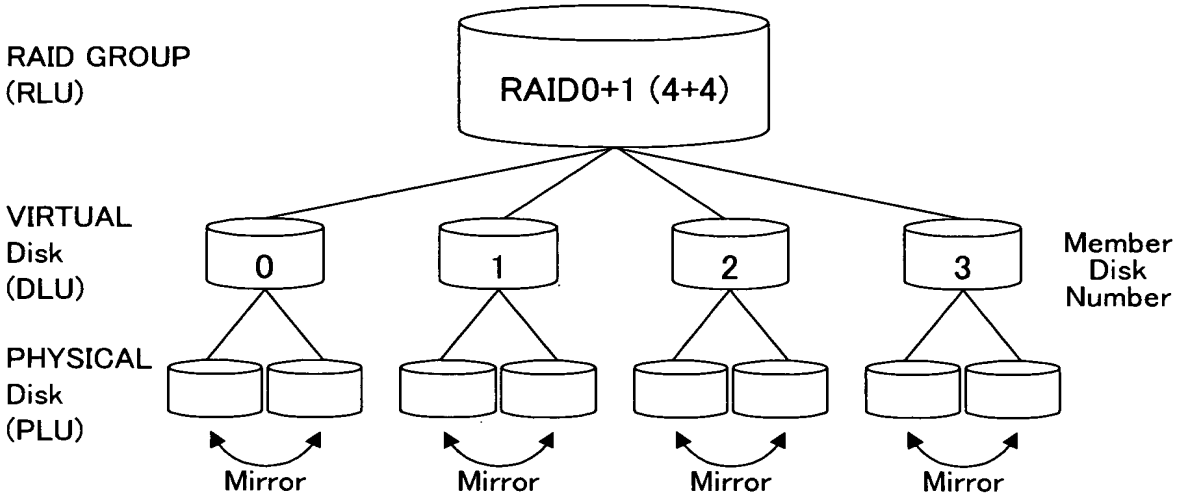

S10
Calculate RAID Group LBA (RLU LBA) from HOST Start LBA
(Add StartRLBA of Logical Volume Information Table (OLU)
DLU LBA = RLU LBA)
S12
Block Count in Strip = Reminder of RLU LBA / Strip size
S14
strip Number = RLU LBA / Strip Depth
S16
stripe Number = RLU LBA / Strip size
S18
Sequence in Member Disk = Reminder of Strip Number / Number of Member Disk
S20
LBA of Physical Disk (PLU)= stripe Number x Strip size
+ Block Count in Strip

FIG. 6


RAID GROUP
(RLU)
RAID0+1 (4+4)
VIRTUAL
Disk
(DLU)
0
1
2
3
Member
Disk
Number
PHYSICAL
Disk
(PLU)
Mirror
Mirror
Mirror
Mirror

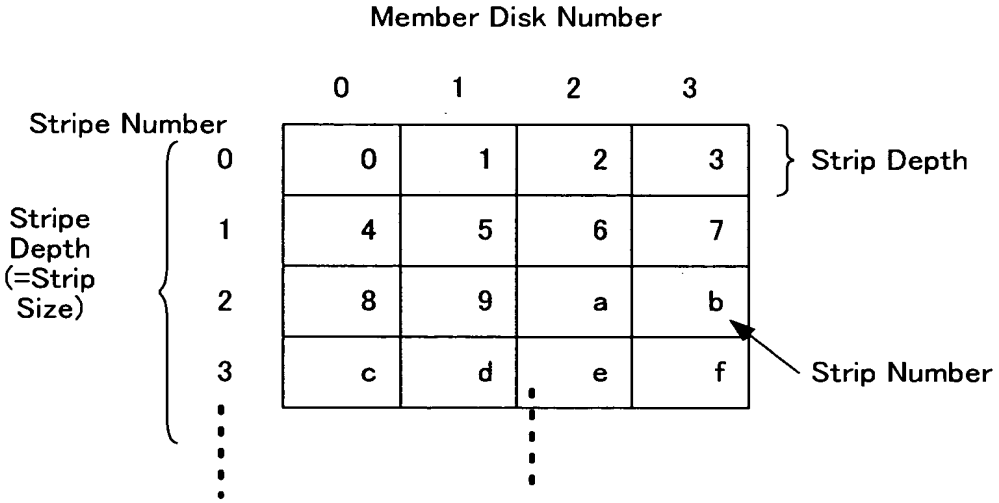

Member Disk Number
0
1
2
3
Stripe Number
0
1
2
3
Strip Depth
Stripe
Depth
(=Strip
Size)
0
1
2
3
4
5
6
7
8
9
a
b
c
d
e
f
Strip Number

FIG. 7

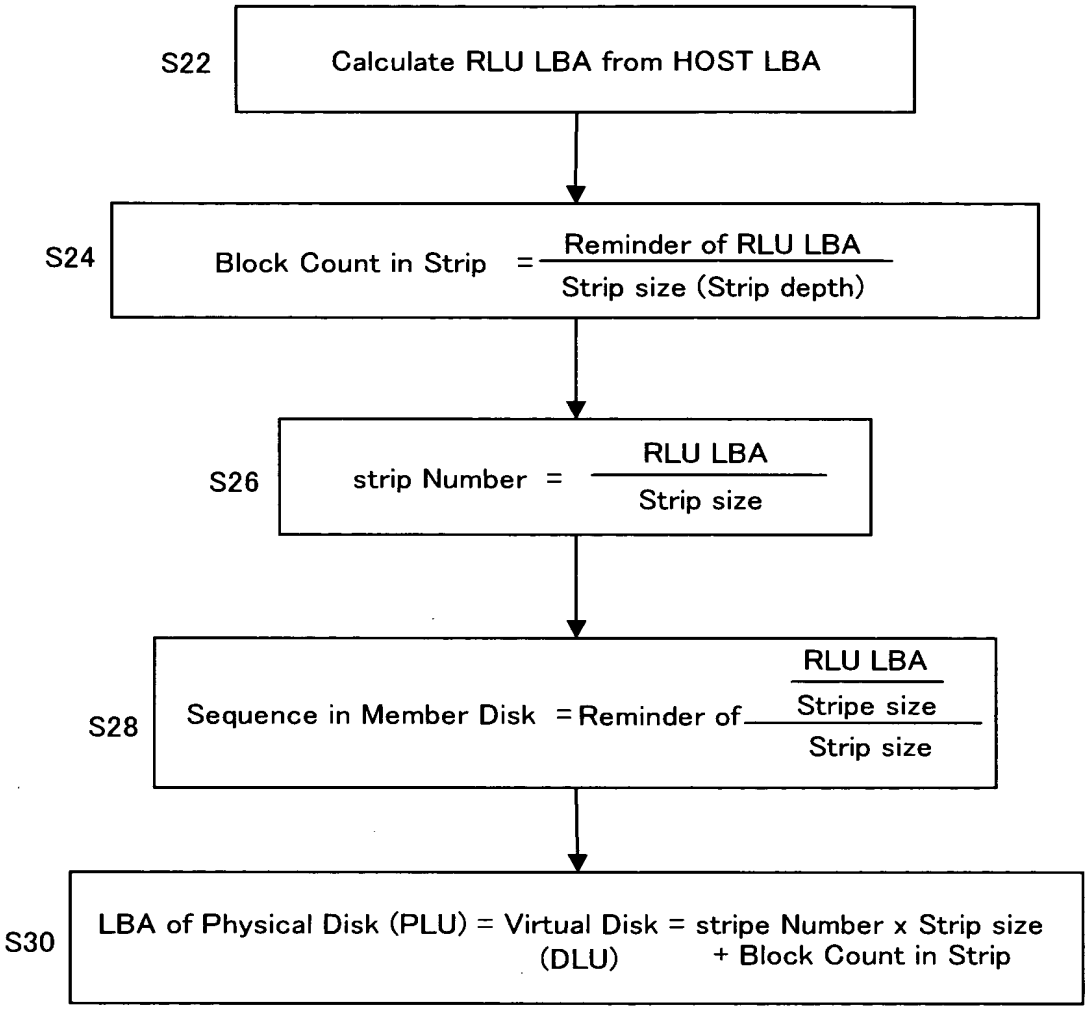

S22
Calculate RLU LBA from HOST LBA
S24
Block Count in Strip = Reminder of RLU LBA / Strip size (Strip depth)
S26
strip Number = RLU LBA / Strip size
S28
Sequence in Member Disk = Reminder of (RLU LBA / Stripe size) / Strip size
S30
LBA of Physical Disk (PLU) = Virtual Disk (DLU) = stripe Number x Strip size + Block Count in Strip

FIG. 8

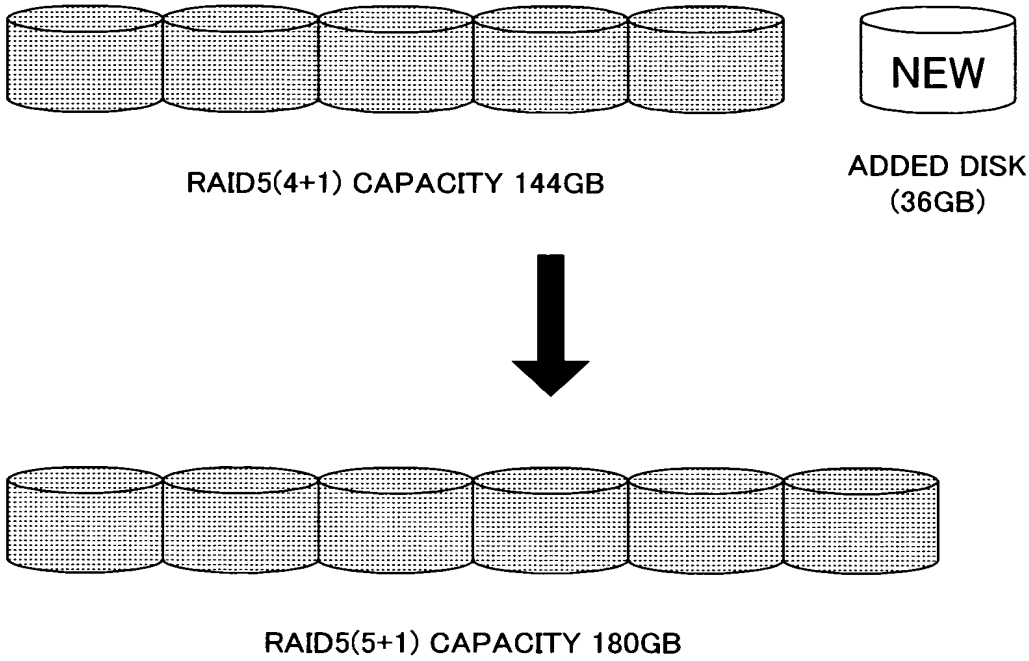

NEW
RAID5(4+1) CAPACITY 144GB
ADDED DISK
(36GB)
RAID5(5+1) CAPACITY 180GB

FIG. 9

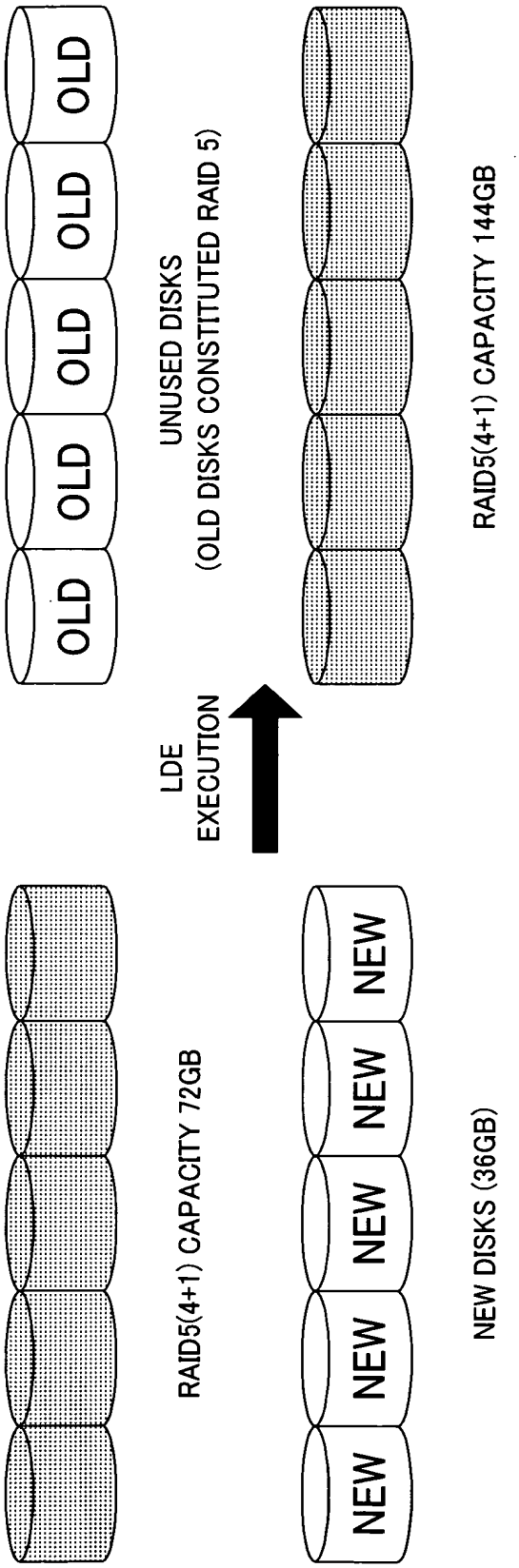

OLD
OLD
OLD
OLD
OLD
UNUSED DISKS
(OLD DISKS CONSTITUTED RAID 5)
RAID5(4+1) CAPACITY 144GB
LDE
EXECUTION
NEW
NEW
NEW
NEW
NEW
NEW DISKS (36GB)
RAID5(4+1) CAPACITY 72GB

FIG. 10

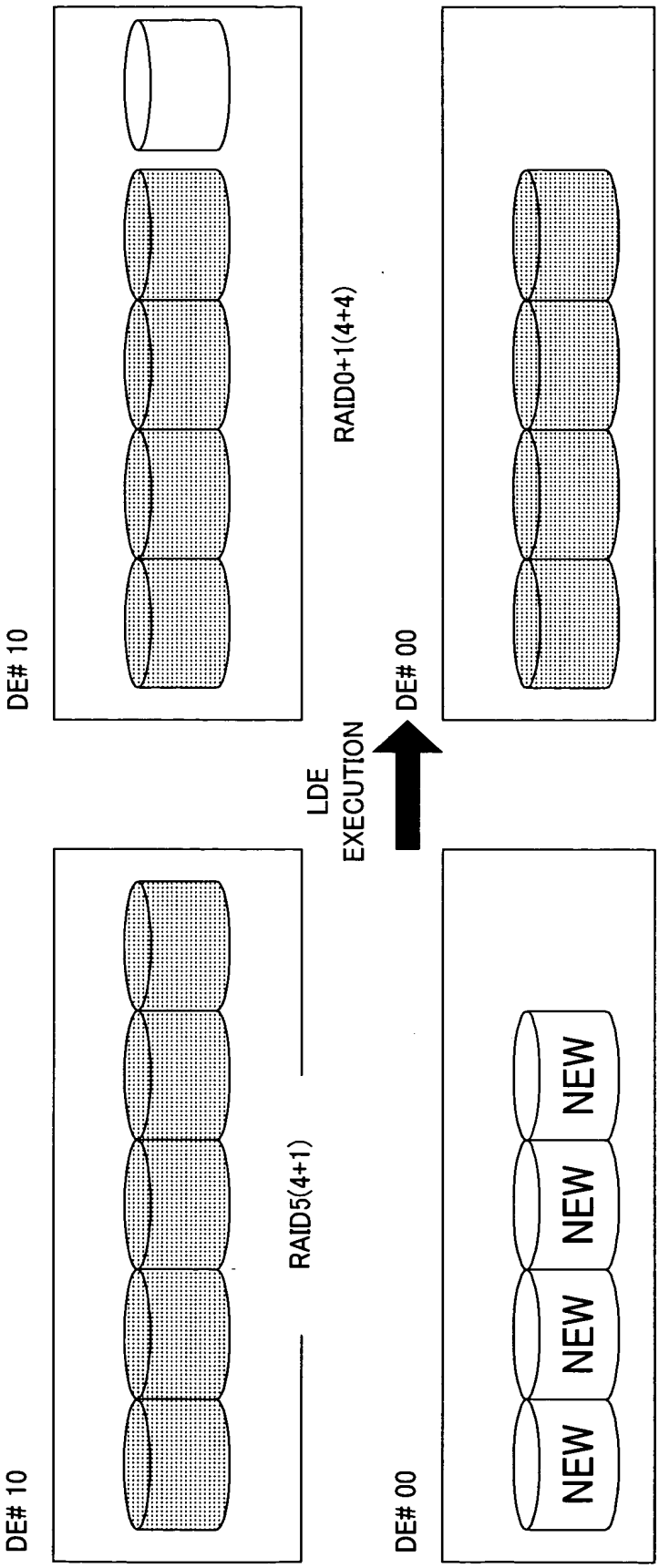

DE# 10
RAID5(4+1)
DE# 00
NEW
NEW
NEW
NEW
LDE
EXECUTION
DE# 10
RAID0+1(4+4)
DE# 00

FIG. 11

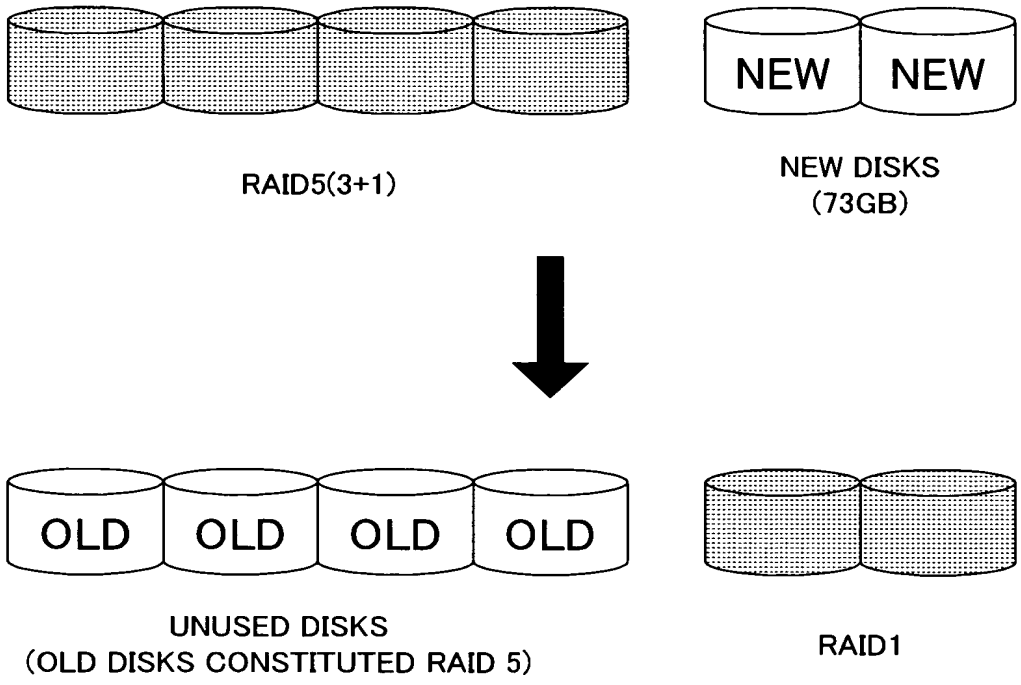

NEW
NEW
RAID5(3+1)
NEW DISKS
(73GB)
OLD
OLD
OLD
OLD
UNUSED DISKS
(OLD DISKS CONSTITUTED RAID 5)
RAID1

FIG. 12

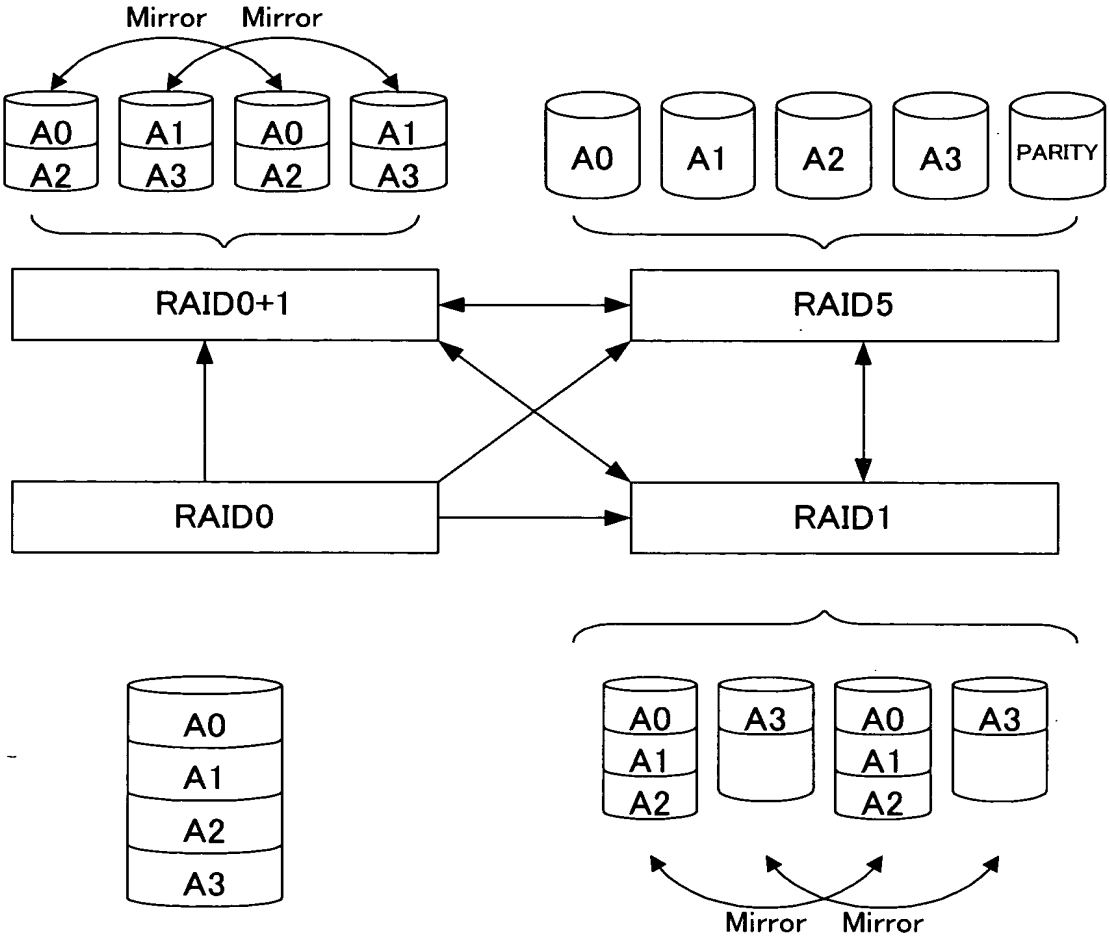

Mirror
Mirror
A0
A2
A1
A3
A0
A2
A1
A3
A0
A1
A2
A3
PARITY
RAID0+1
RAID5
RAID0
RAID1
A0
A1
A2
A3
A0
A1
A2
A3
A0
A1
A2
A3
Mirror
Mirror

FIG. 13

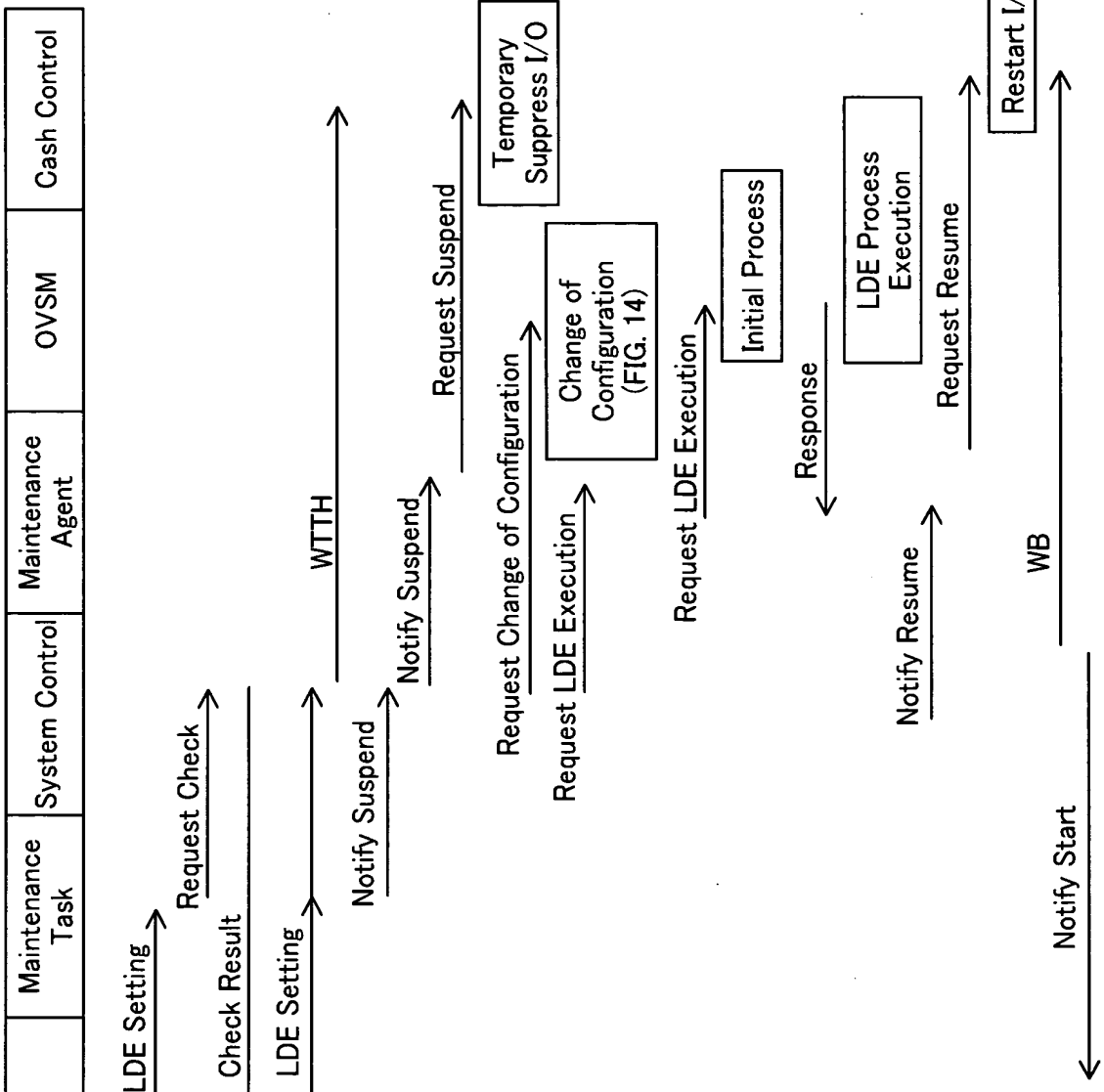
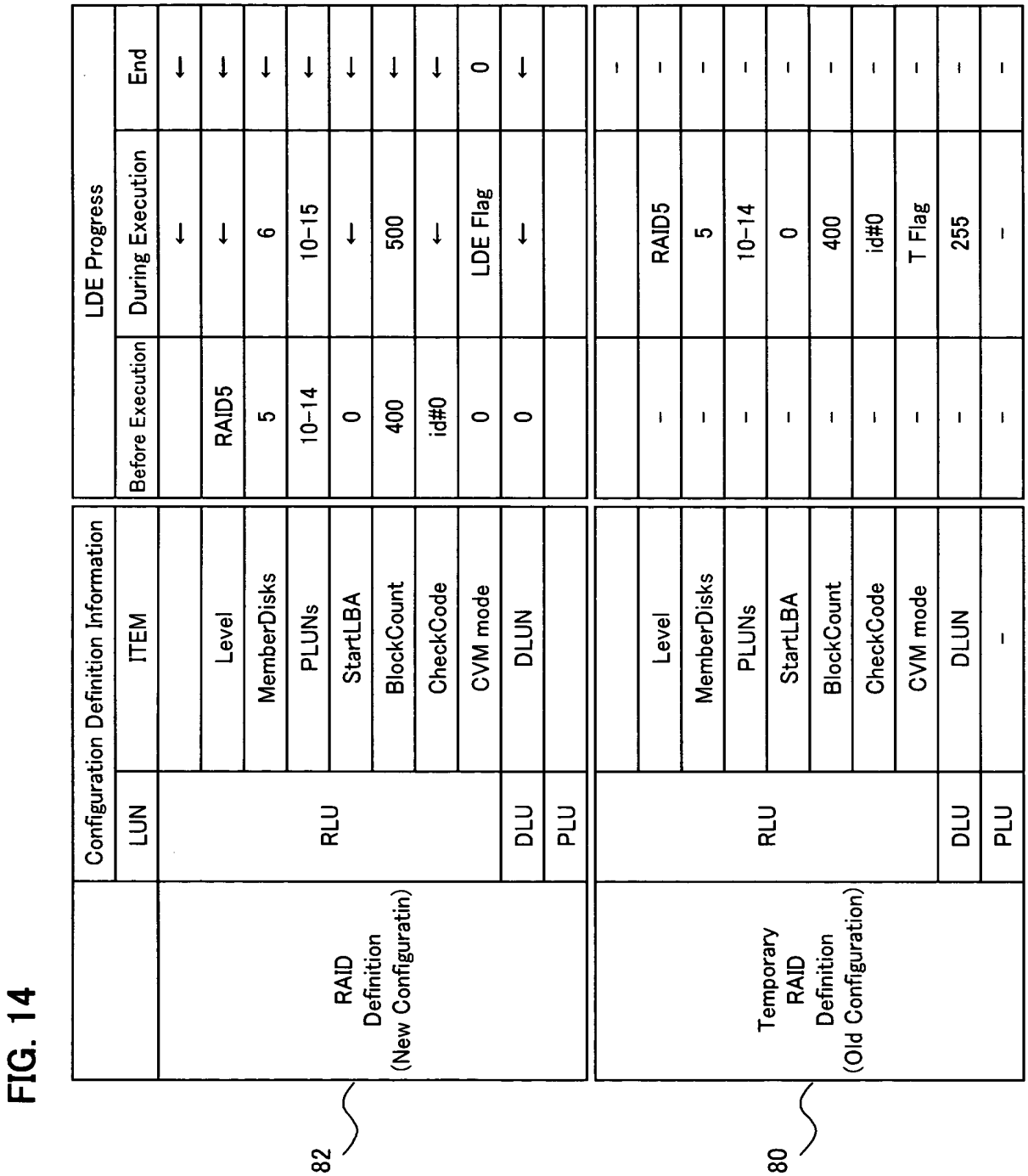

CGI
Maintenance Task
System Control
Maintenance Agent
OVSM
Cash Control
Notify LDE Setting
Request Check
Check Result
LDE Setting
WTTH
Notify Suspend
Notify Suspend
Request Suspend
Temporary Suppress I/O
Request Change of Configuration
Request LDE Execution
Change of Configuration (FIG. 14)
Request LDE Execution
Initial Process
Response
LDE Process Execution
Notify Resume
Request Resume
Restart I/O
WB
Notify Start

FIG. 14



	Configuration Definition Information		LDE Progress		
	LUN	ITEM	Before Execution	During Execution	End
RAID Definition (New Configuratin)	RLU	Level		←	←
		MemberDisks	RAID5	←	←
		PLUNs	5	6	←
		StartLBA	10–14	10–15	←
		BlockCount	0	←	←
		CheckCode	400	500	←
		CVM mode	id#0	←	←
	DLU	DLUN	0	LDE Flag	0
	PLU		0	←	←
Temporary RAID Definition (Old Configuration)	RLU	Level	–	RAID5	–
		MemberDisks	–	5	–
		PLUNs	–	10–14	–
		StartLBA	–	0	–
		BlockCount	–	400	–
		CheckCode	–	id#0	–
		CVM mode	–	T Flag	–
	DLU	DLUN	–	255	–
	PLU	–	–	–	–

FIG. 15

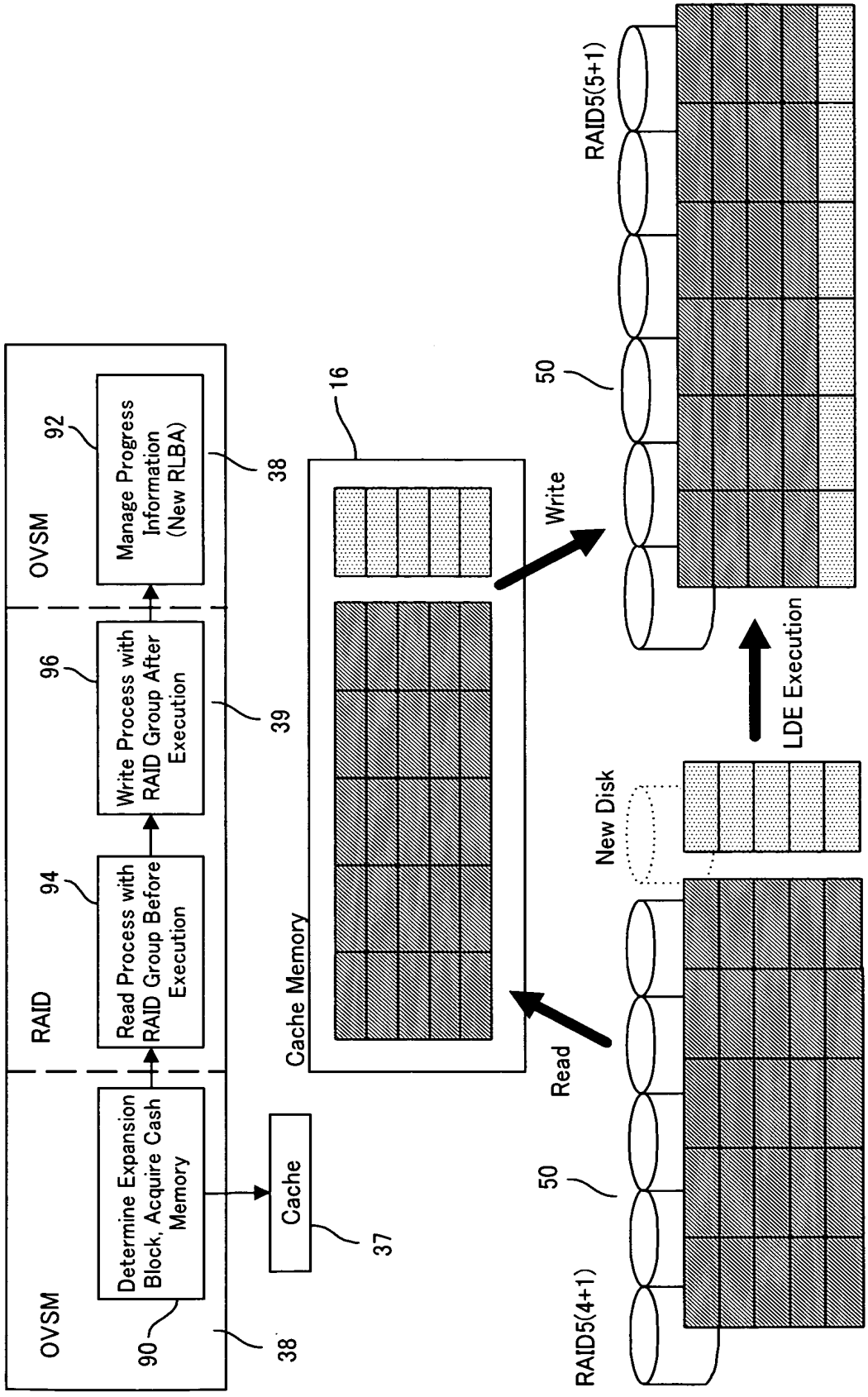

OVSM
Determine Expansion Block, Acquire Cash Memory
90
38
Cache
37
RAID
Read Process with RAID Group Before Execution
94
Write Process with RAID Group After Execution
96
39
OVSM
Manage Progress Information (New RLBA)
92
38
16
Cache Memory
Read
Write
50
RAID5(4+1)
New Disk
LDE Execution
50
RAID5(5+1)

FIG. 16

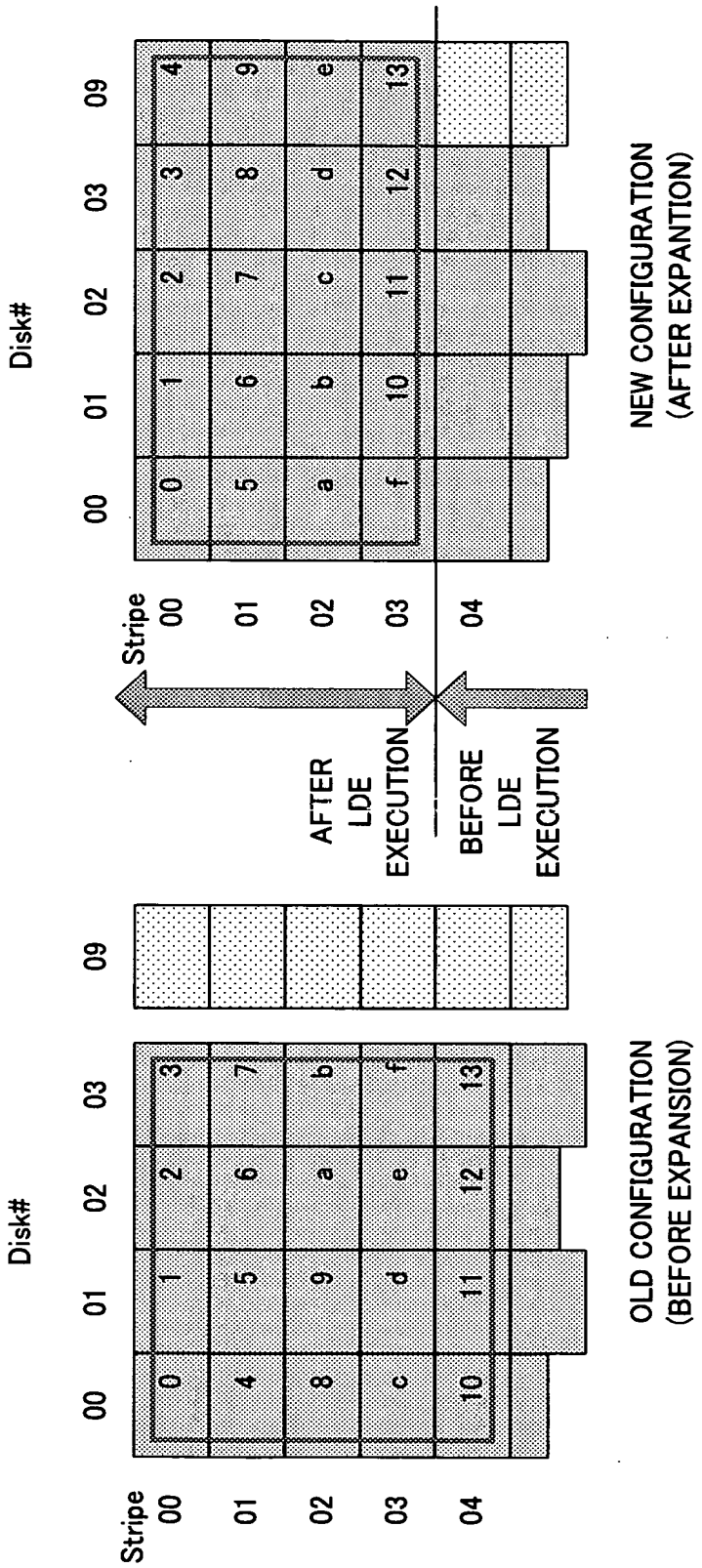

Disk#
00
01
02
03
09
Stripe
00
01
02
03
04
0
1
2
3
4
5
6
7
8
9
a
b
c
d
e
f
10
11
12
13
AFTER LDE EXECUTION
BEFORE LDE EXECUTION
NEW CONFIGURATION (AFTER EXPANTION)
OLD CONFIGURATION (BEFORE EXPANSION)

FIG. 17

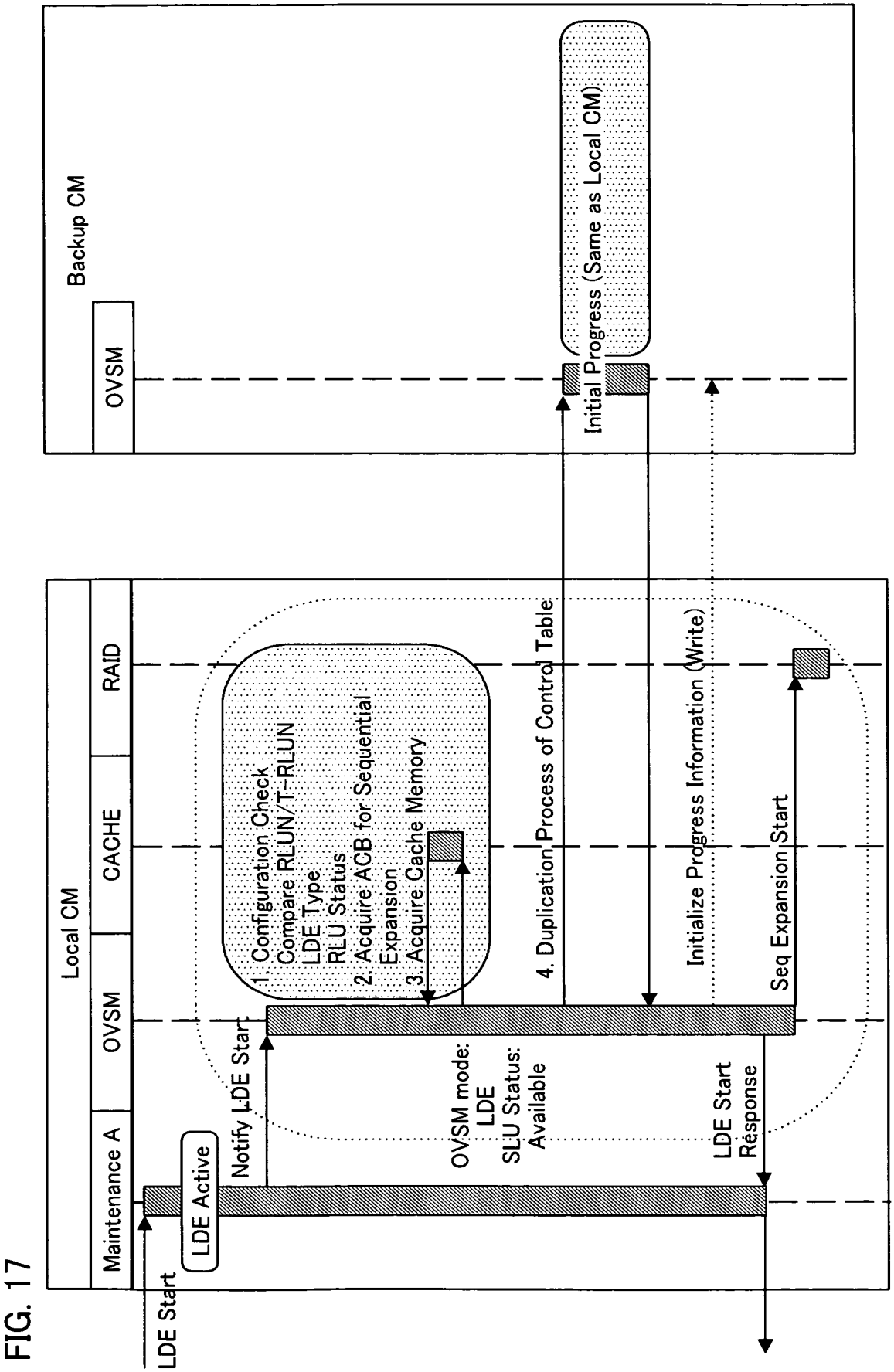

Backup CM
OVSM
Initial Progress (Same as Local CM)
Local CM
Maintenance A
OVSM
CACHE
RAID
LDE Start
LDE Active
Notify LDE Start
1. Configuration Check
Compare RLUN/T-RLUN
LDE Type
RLU Status
2. Acquire ACB for Sequential Expansion
3. Acquire Cache Memory
4. Duplication Process of Control Table
Initialize Progress Information (Write)
Seq Expansion Start
OVSM mode: LDE
SLU Status: Available
LDE Start Response

FIG. 18

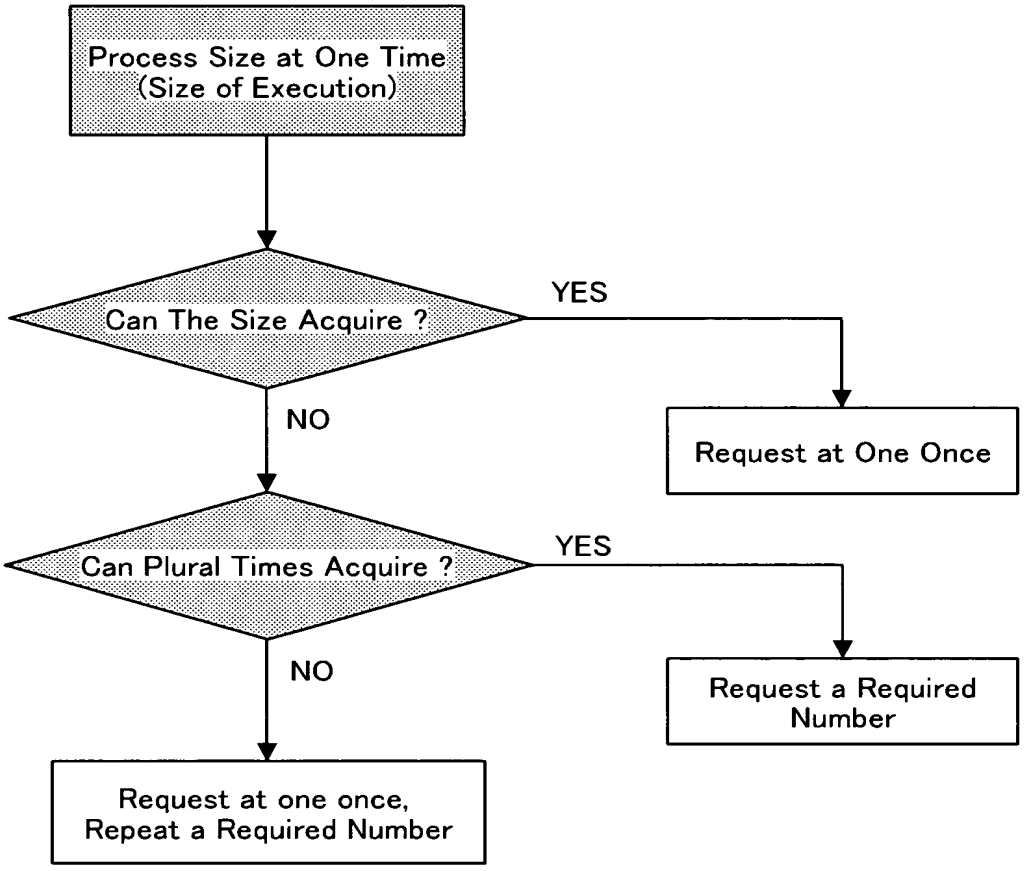

Process Size at One Time
(Size of Execution)
Can The Size Acquire ?
YES
NO
Request at One Once
Can Plural Times Acquire ?
YES
NO
Request a Required
Number
Request at one once,
Repeat a Required Number

FIG. 19

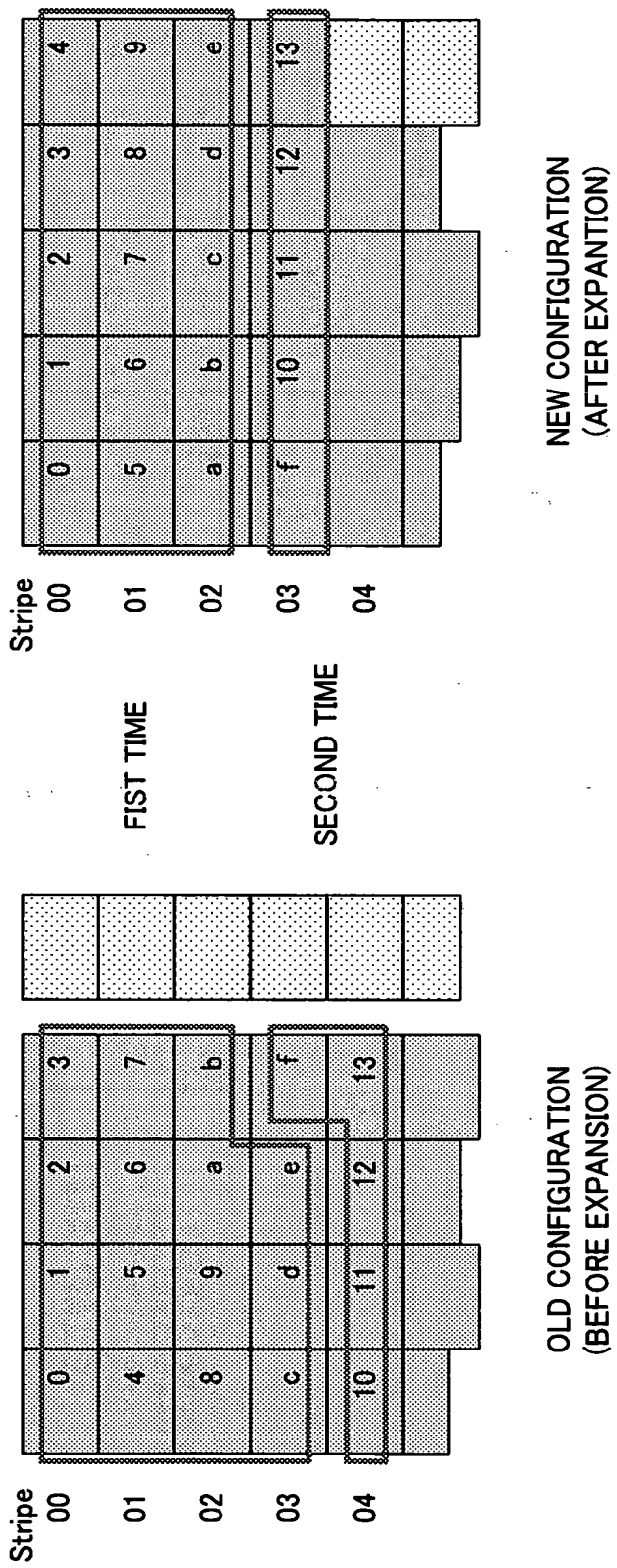

Disk#
00
01
02
03
09
Stripe
00
01
02
03
04
FIST TIME
SECOND TIME
OLD CONFIGURATION
(BEFORE EXPANSION)
NEW CONFIGURATION
(AFTER EXPANTION)

FIG. 20

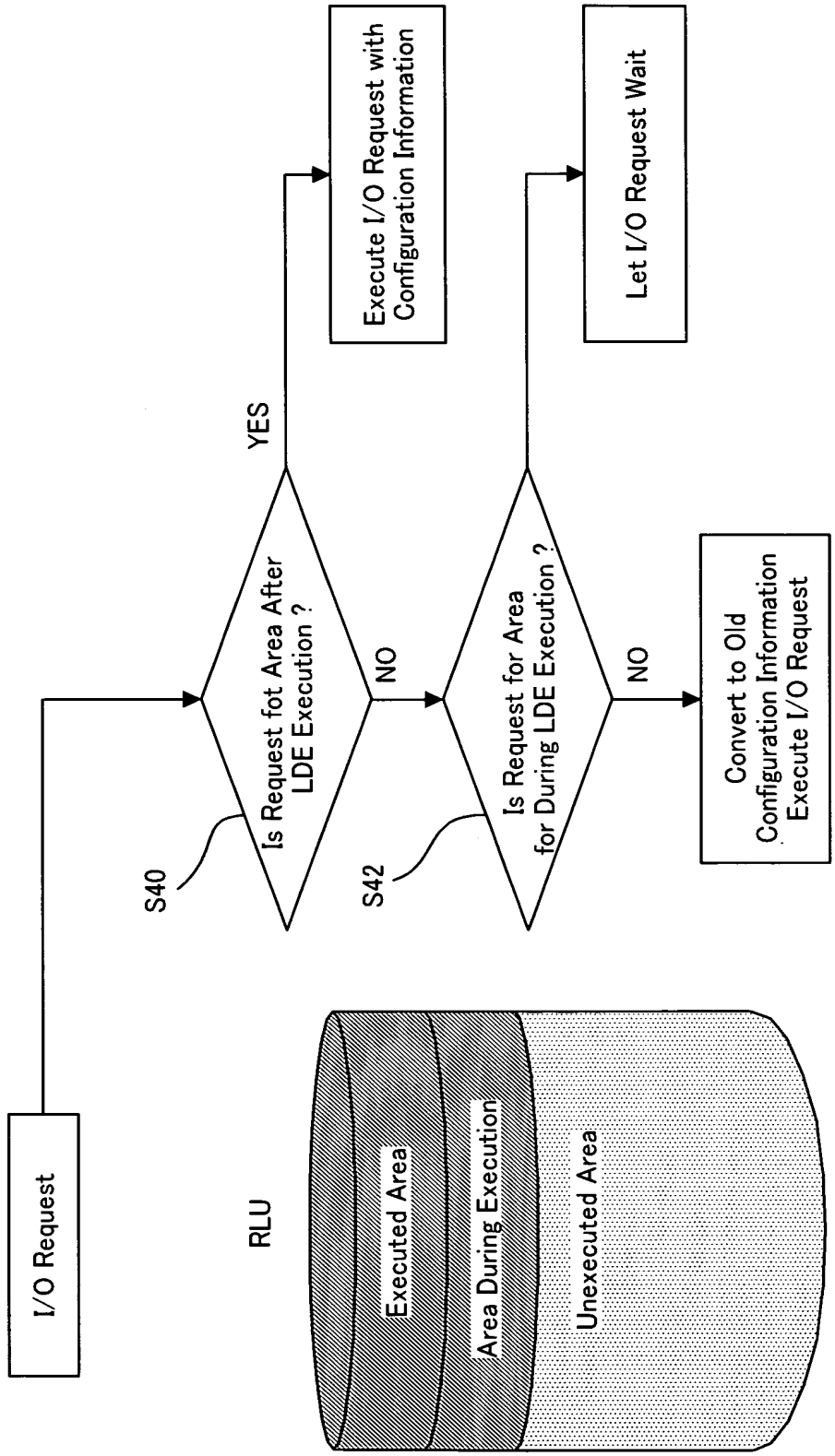

I/O Request
S40
Is Request fot Area After LDE Execution ?
YES
Execute I/O Request with Configuration Information
NO
S42
Is Request for Area for During LDE Execution ?
YES
Let I/O Request Wait
NO
Convert to Old Configuration Information Execute I/O Request
RLU
Executed Area
Area During Execution
Unexecuted Area
Exclusive
NO
YES
NO

FIG. 21

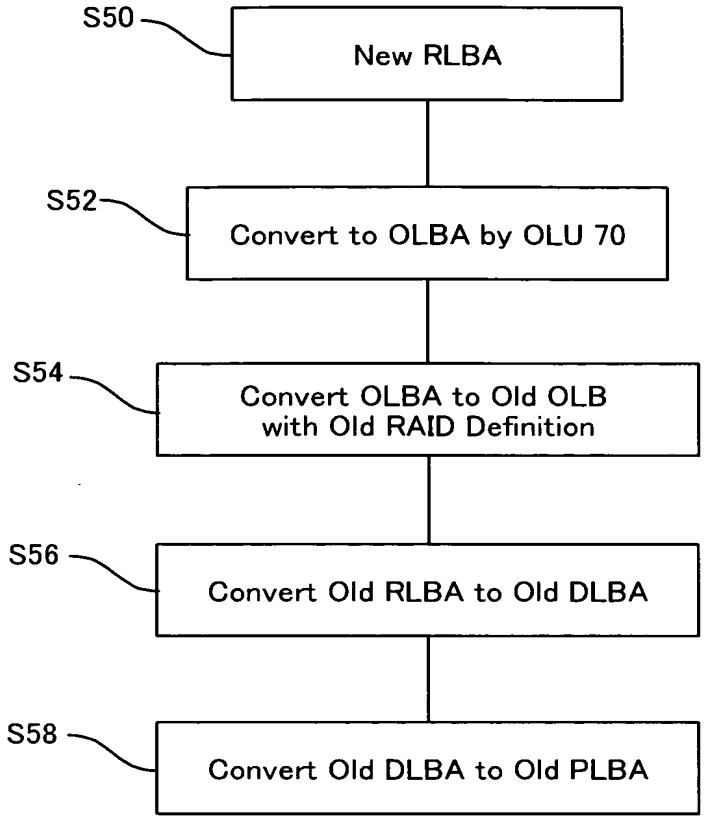

S50
New RLBA
S52
Convert to OLBA by OLU 70
S54
Convert OLBA to Old OLB with Old RAID Definition
S56
Convert Old RLBA to Old DLBA
S58
Convert Old DLBA to Old PLBA

FIG. 22

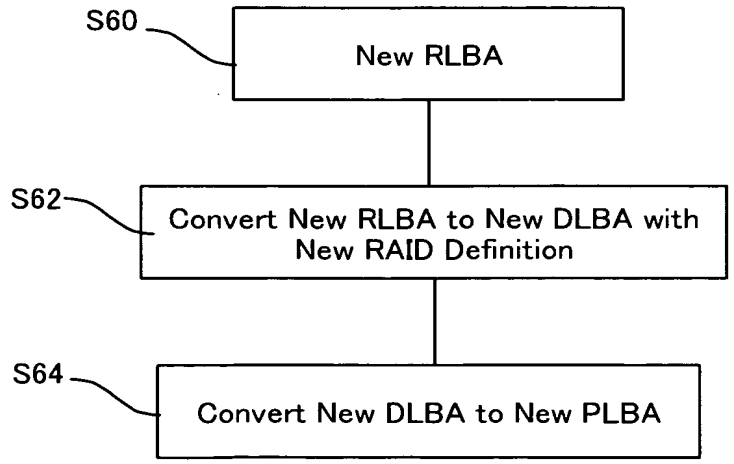

S60
New RLBA
S62
Convert New RLBA to New DLBA with New RAID Definition
S64
Convert New DLBA to New PLBA

FIG. 23

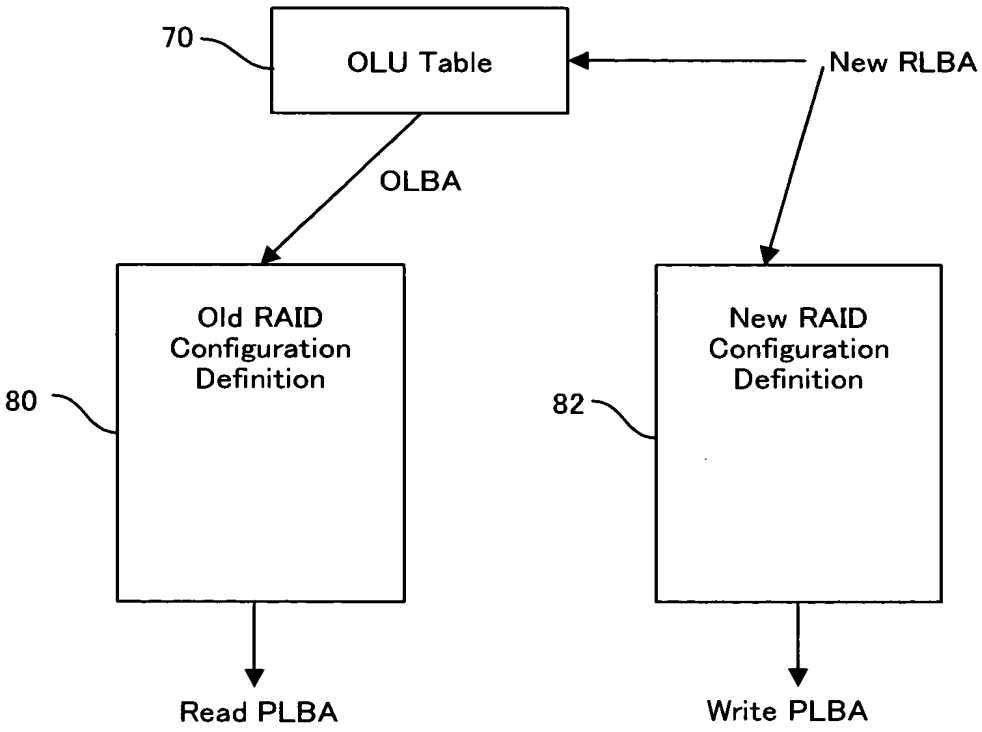

70
OLU Table
New RLBA
OLBA
Old RAID Configuration Definition
80
New RAID Configuration Definition
82
Read PLBA
Write PLBA

FIG. 24

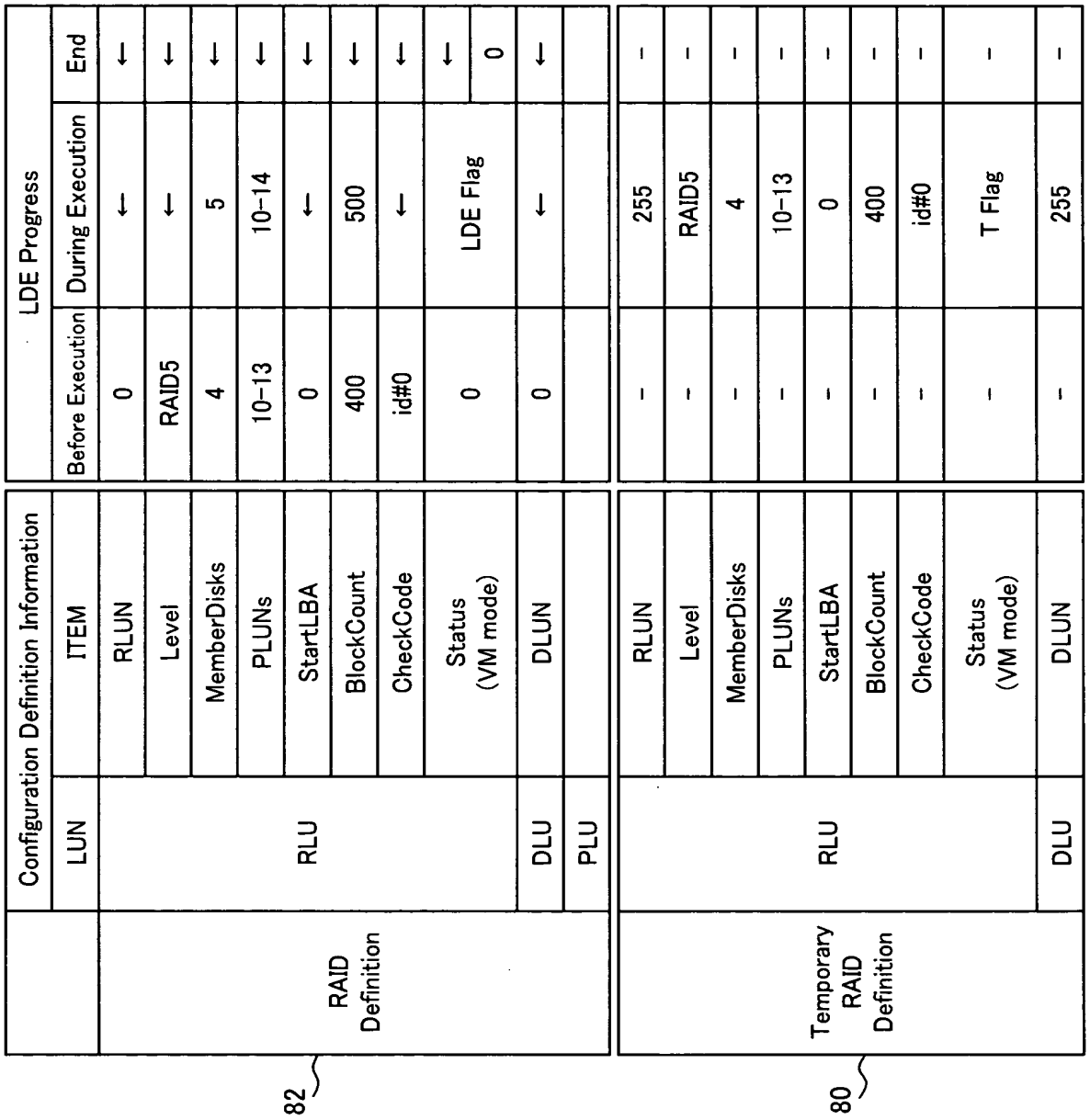

82
RAID Definition
Configuration Definition Information
LUN
ITEM
LDE Progress
Before Execution
During Execution
End
RLU
RLUN
0
←
←
Level
RAID5
←
←
MemberDisks
4
5
←
PLUNs
10-13
10-14
←
StartLBA
0
←
←
BlockCount
400
500
←
CheckCode
id#0
←
←
Status (VM mode)
0
LDE Flag
←
0
DLU
DLUN
0
←
←
PLU
80
Temporary RAID Definition
RLU
RLUN
-
255
-
Level
-
RAID5
-
MemberDisks
-
4
-
PLUNs
-
10-13
-
StartLBA
-
0
-
BlockCount
-
400
-
CheckCode
-
id#0
-
Status (VM mode)
-
T Flag
-
DLU
DLUN
-
255
-

FIG. 25

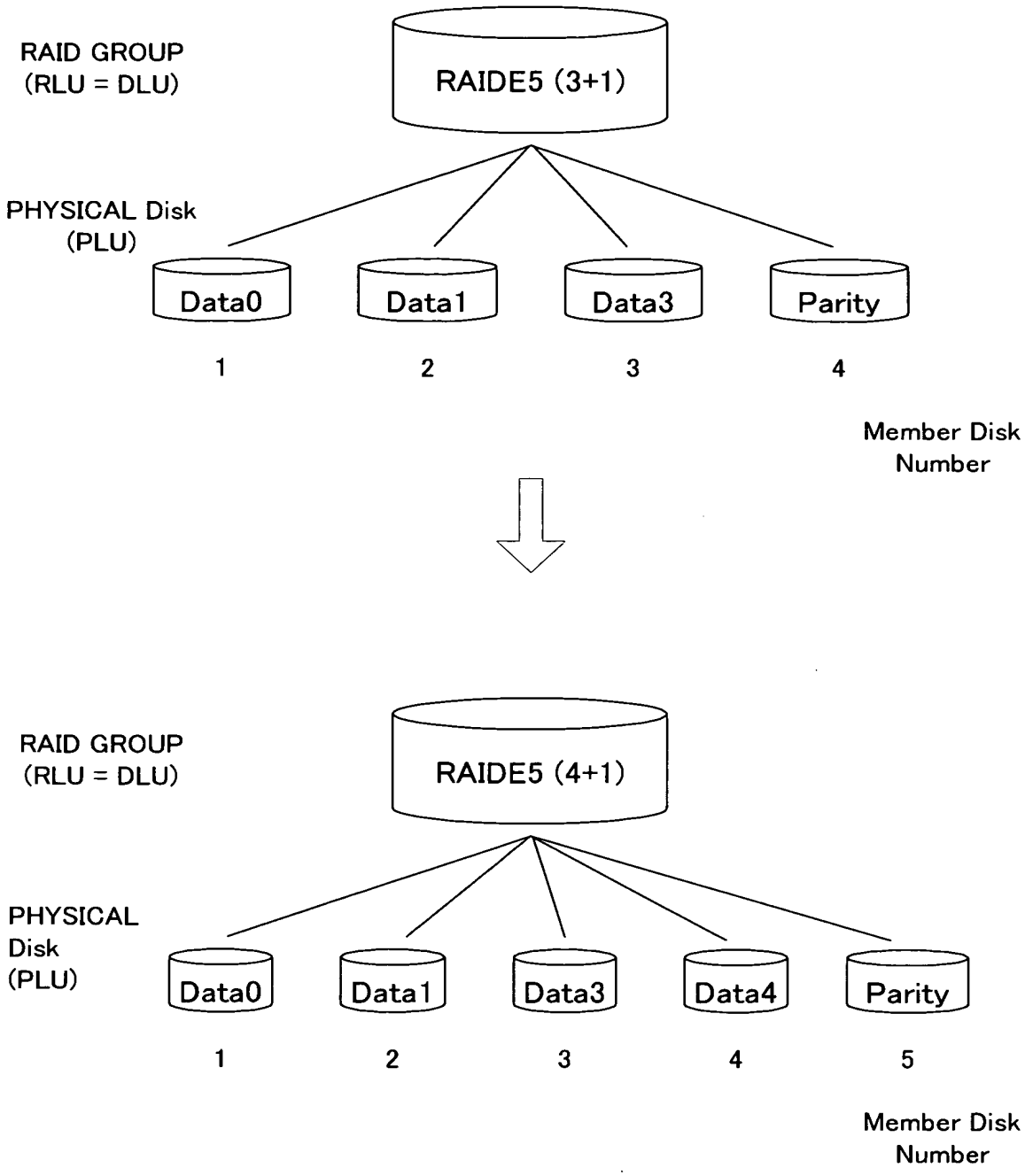

RAID GROUP
(RLU = DLU)
RAIDE5 (3+1)
PHYSICAL Disk
(PLU)
Data0
Data1
Data3
Parity
1
2
3
4
Member Disk
Number
RAID GROUP
(RLU = DLU)
RAIDE5 (4+1)
PHYSICAL
Disk
(PLU)
Data0
Data1
Data3
Data4
Parity
1
2
3
4
5
Member Disk
Number

FIG. 26

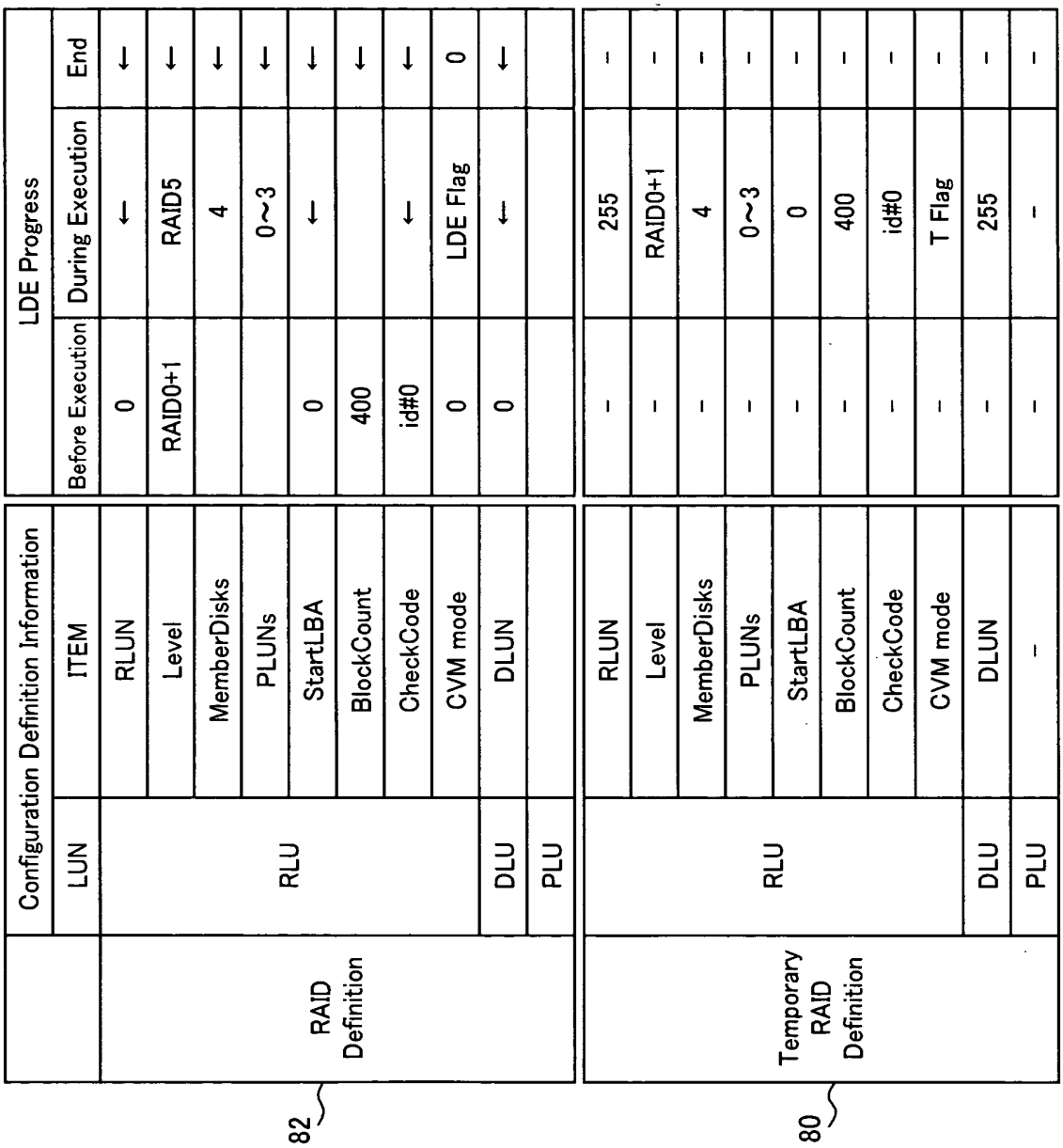

82
RAID Definition
Configuration Definition Information
LUN
ITEM
LDE Progress
Before Execution
During Execution
End
RLU
RLUN
0
←
←
Level
RAID0+1
RAID5
←
MemberDisks
4
←
PLUNs
0~3
←
StartLBA
0
←
←
BlockCount
400
←
CheckCode
id#0
←
←
CVM mode
0
LDE Flag
0
DLU
DLUN
0
←
←
PLU
80
Temporary RAID Definition
RLU
RLUN
-
255
-
Level
-
RAID0+1
-
MemberDisks
-
4
-
PLUNs
-
0~3
-
StartLBA
-
0
-
BlockCount
-
400
-
CheckCode
-
id#0
-
CVM mode
-
T Flag
-
DLU
DLUN
-
255
-
PLU
-
-
-
-

FIG. 27

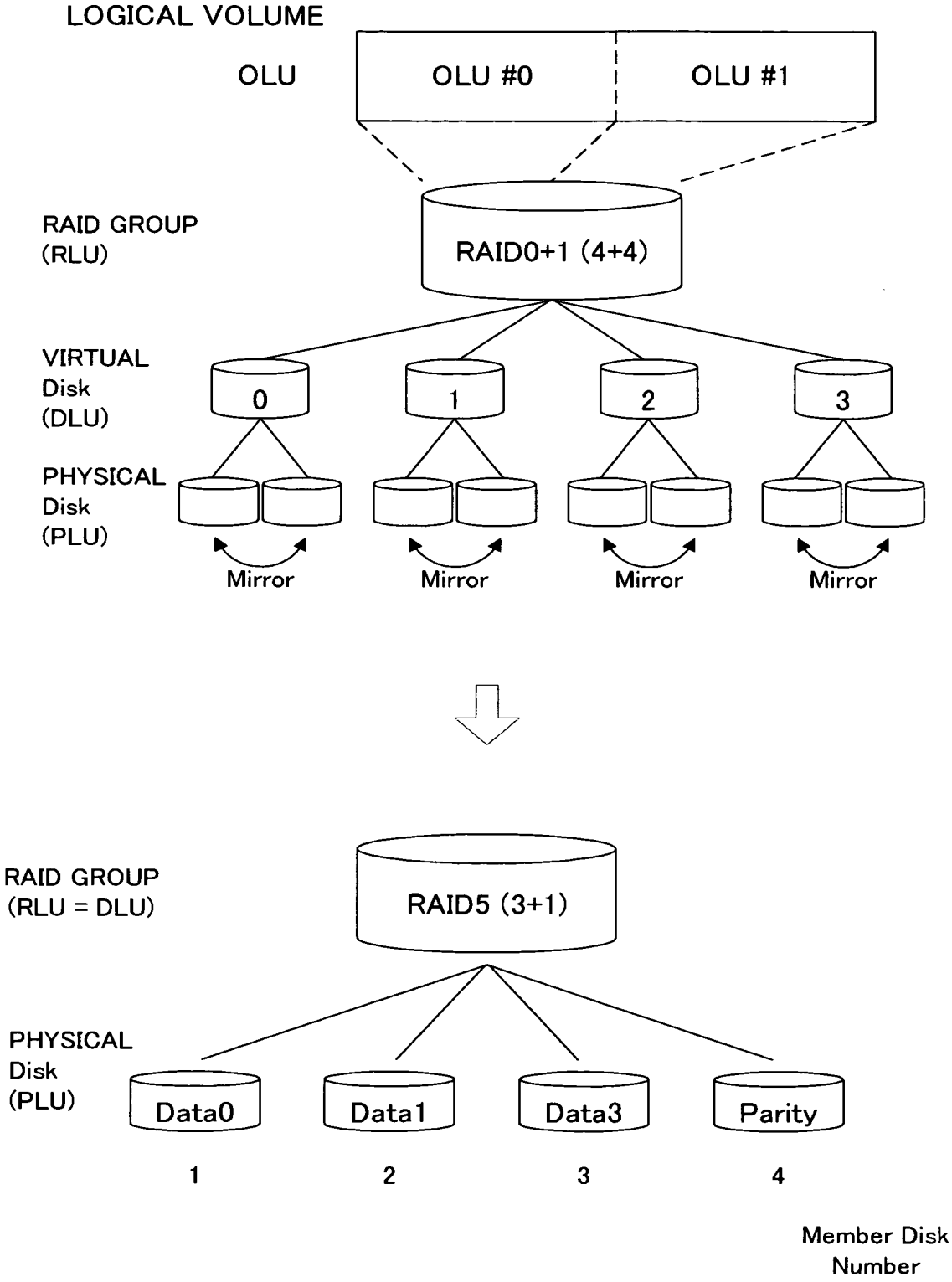
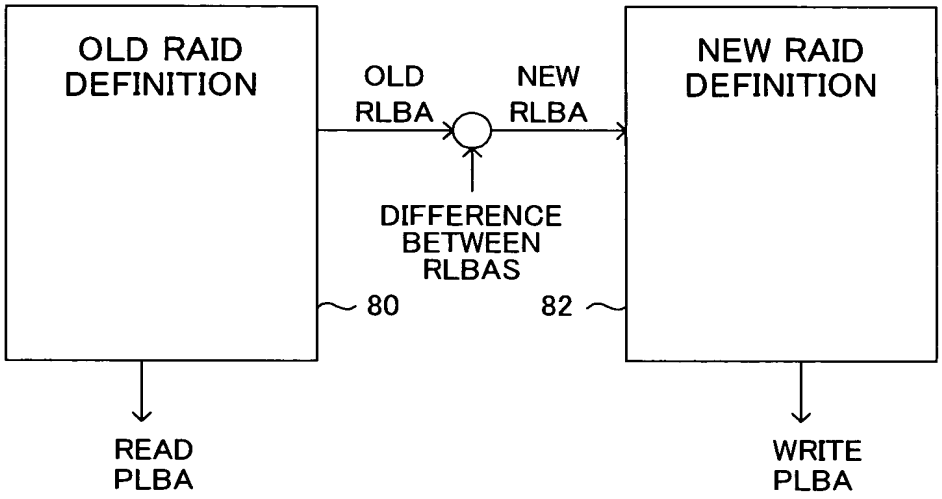

LOGICAL VOLUME
OLU
OLU #0
OLU #1
RAID GROUP
(RLU)
RAID0+1 (4+4)
VIRTUAL
Disk
(DLU)
0
1
2
3
PHYSICAL
Disk
(PLU)
Mirror
Mirror
Mirror
Mirror
RAID GROUP
(RLU = DLU)
RAID5 (3+1)
PHYSICAL
Disk
(PLU)
Data0
Data1
Data3
Parity
1
2
3
4
Member Disk
Number

FIG. 28

RLU		DLU 1	
RAID Level	0+1	Stripe Depth	128
Stripe Depth	128	Stripe Size	128
Stripe Size	128x4	Member Disk Count	2
Member Disk Count	4	DLU 2	
		DLU 3	
		DLU 4	

RLU		DLU	
RAID Level	5	Stripe Depth	128
Stripe Depth	128x3	Stripe Size	128x3
Stripe Size	128x3	Member Disk Count	4
Member Disk Count	1		

FIG. 29


OLD RAID DEFINITION
OLD RLBA
NEW RLBA
NEW RAID DEFINITION
DIFFERENCE BETWEEN RLBAS
80
82
READ PLBA
WRITE PLBA